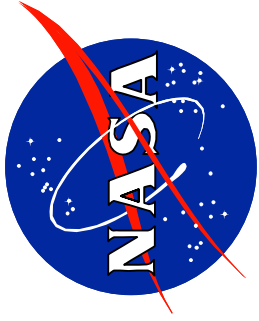


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Behavioral Sciences

*NASA/Johnson Space
Center*

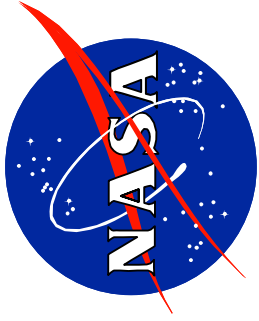
*with thanks to Dennis Wells
Automation, Robotics, and Simulation Division*



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Purpose

- Putting humans in space is an expensive, sometimes risky endeavor.
- Our goal is to enhance the role of humans in space by developing autonomous systems that support human functions in orbit and on planetary surfaces.



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Vision

- **We are developing technologies that allow humans to do what they are best at**
 - Allow science missions to focus nearly all scientist time on performing experiments and ‘doing’ science
 - Reduce or eliminate crew time spent on keeping humans alive and their ‘household’ functioning
 - Develop autonomous systems which perform routine operations associated with monitoring, inspection, maintenance, repair, etc.



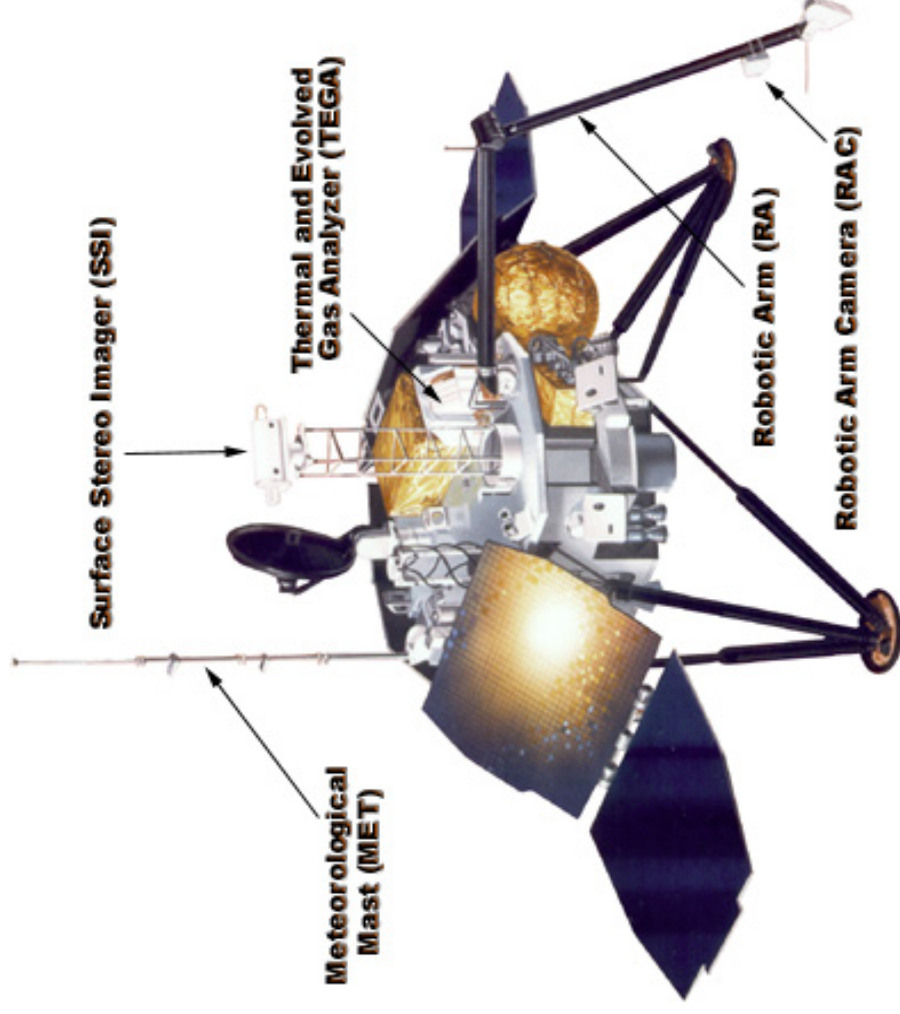
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Current Robots in Space

- Planetary Probes
- Planetary Rovers
- Space Shuttle Arm (Remote Manipulator System or RMS)
- Space Station Arm (SSRMS)

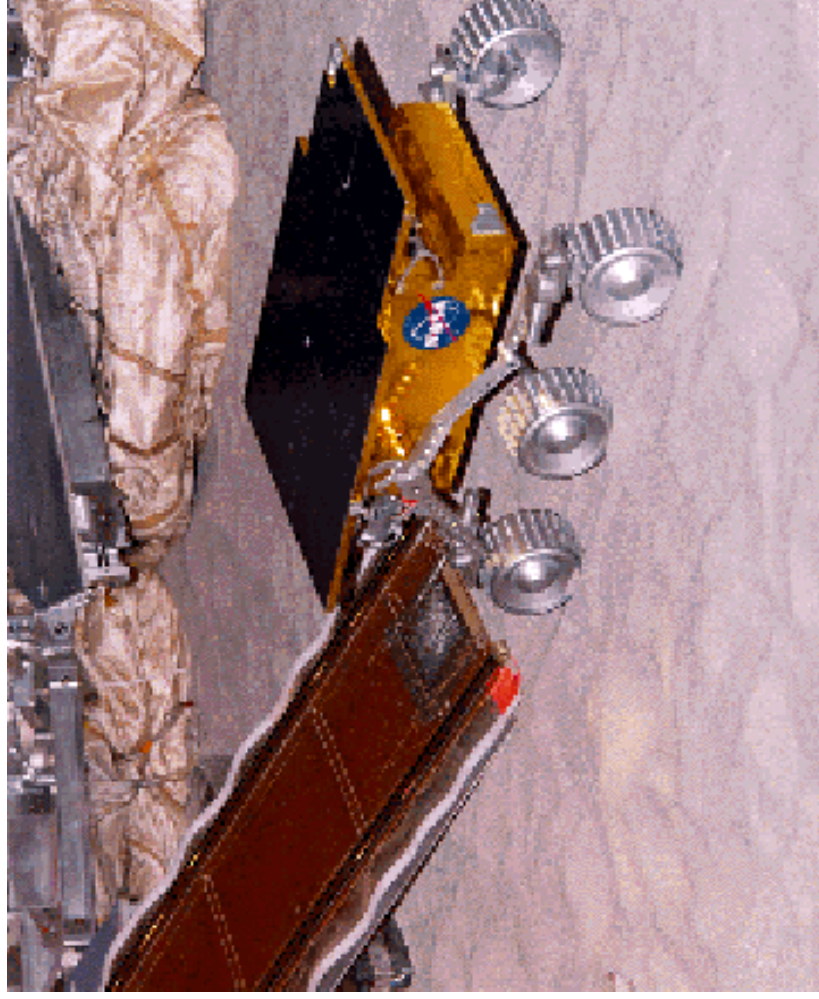


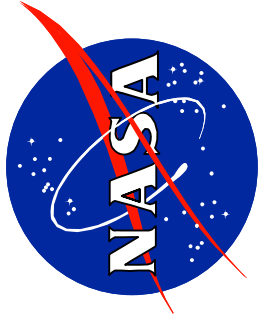


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Current Robots in Space

- Rovers have shown how robotic systems can work without a human presence to explore new environments.





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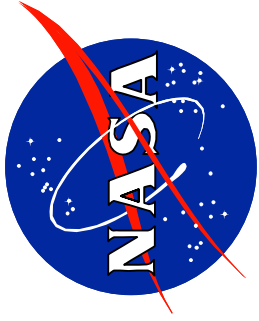
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Current Robots in Space

- **Robots are also important for helping humans work in space.**





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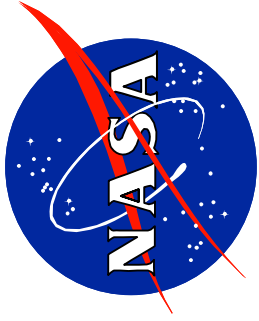
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Ground Based Robots

- **Ground based robots are used to train astronauts how to use the robots in space.**
- **These are very special systems designed to work in Earth's gravity, but still act like the on-orbit system.**





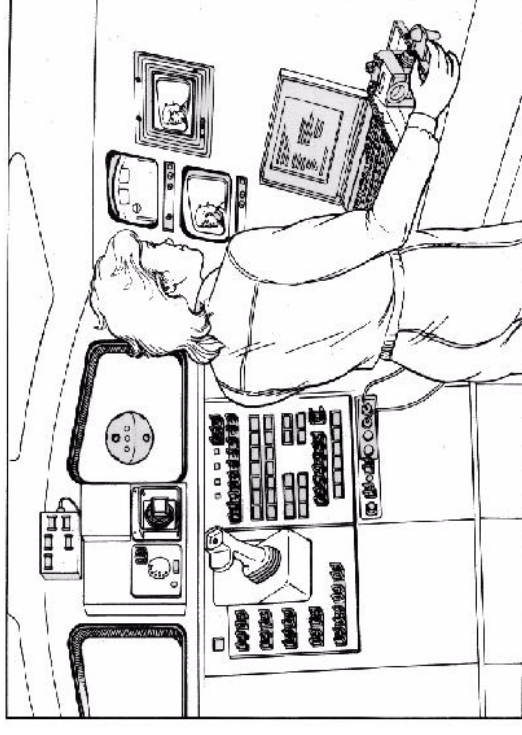
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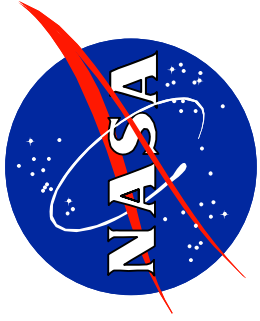
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AERCam

- Autonomous Extravehicular Robotic CAMera
- Concept Description
 - Free-flying robotic platform for visual and non-visual sensing
 - Cold gas propulsion
 - Teleoperated or automated
- AERCam Sprint flight test
 - ISS Risk Mitigation Experiment on STS-87 (Nov 97)
 - Mostly teleoperated, autonomous attitude and safing
- Future application to ISS
 - Interchangeable sensor carrier capability
 - Externally mounted with recharge capability
 - Self-deploy from home base
 - Navigate to region of interest while avoiding collisions





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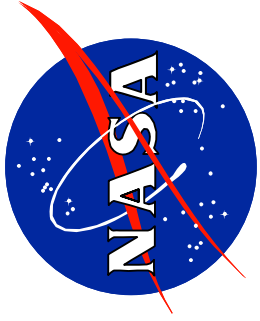
AERCam



Assembly



Environmental testing



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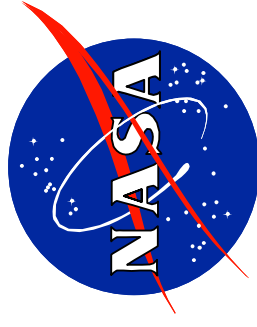
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Integration



Training and Checkout

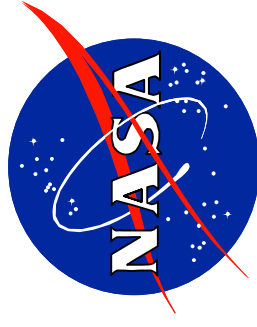


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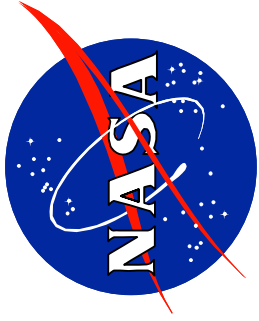


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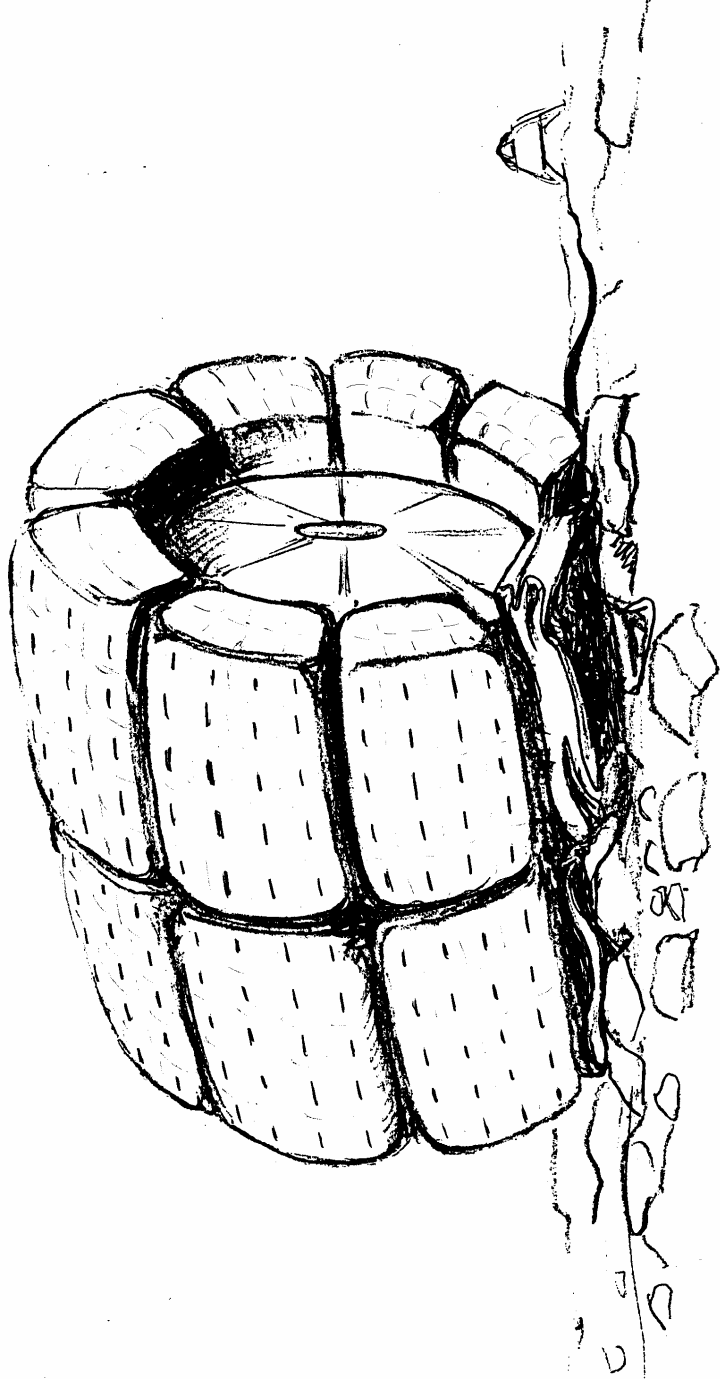


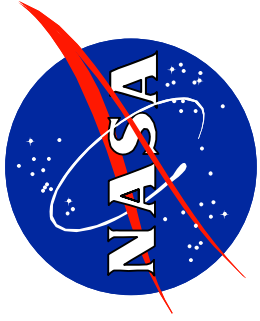


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Rotating Bladder Robot (ROBLR)

- **Concept description**
 - Heavy payload transport over rough Mars terrain with little supervision
- **Key Characteristics**
 - Unmanned
 - Uses Mars air
 - Lightweight
 - Payload is hub
 - Moves by bladder inflation/deflation (moving flat spot)





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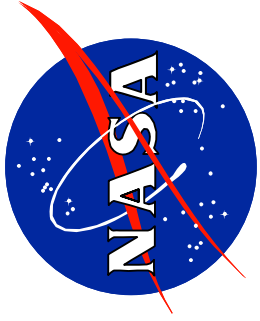
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ROBLR



Concept Demonstrator



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Aspects**

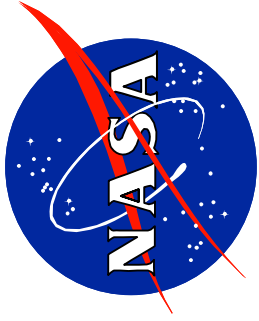
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ROBLR



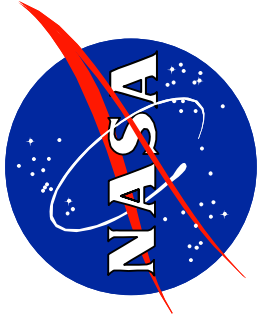
Test



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DART

- The Dexterous Anthropomorphic Robotic Testbed (DART) was the division's first attempt at developing robots that help humans perform space activities. We had three main objectives in the project: (1) develop a dexterous telerobotic system compatible with human telepresence; (2) develop a flexible, shared control architecture such that proven intelligent automation technologies can be easily incorporated to augment telepresence; and (3) demonstrate the benefit of telepresence and dexterous robotics in Space applications. DART was very successful in meeting these objectives and although the Robonaut replaced DART as the primary technology development tool, DART is still used for demonstrations and testing components.

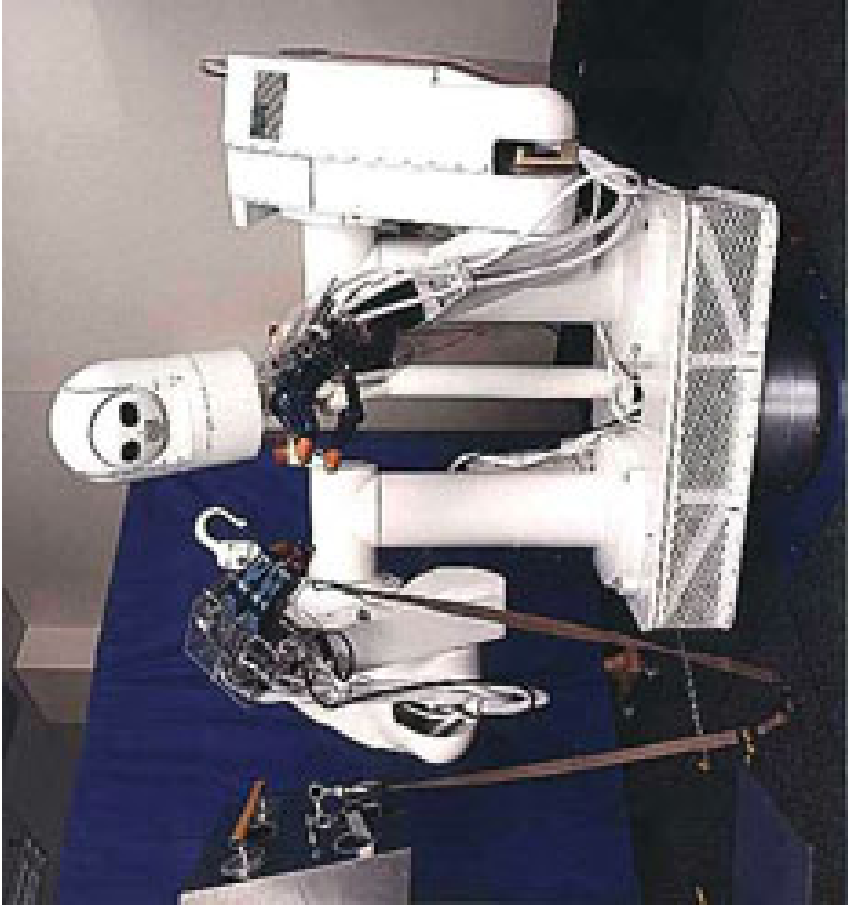


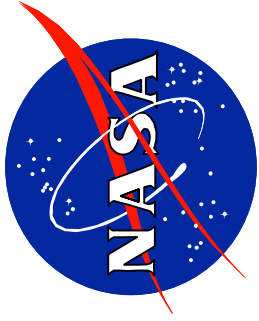
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DART





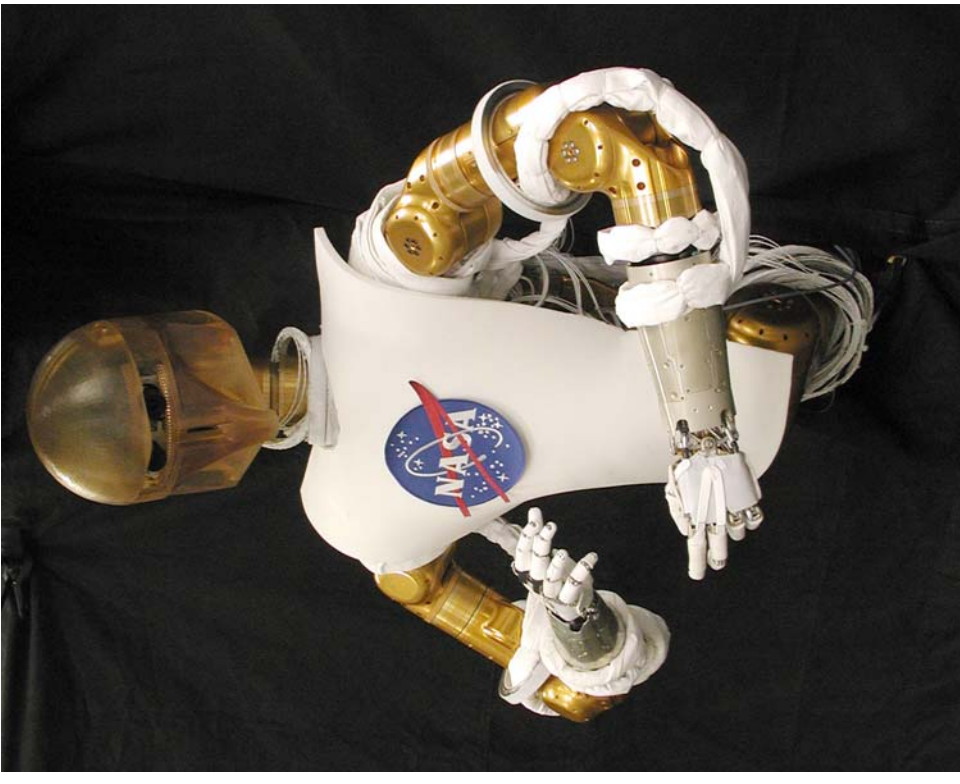
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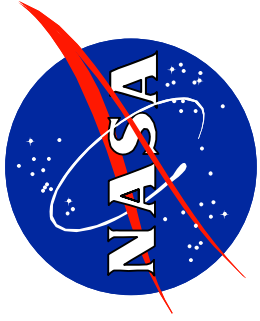
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Robonaut

- **Concept description**
 - Anthropomorphic robot which can function as a EVA crew assistant or complete EVA tasks independently
- **Key Characteristics**
 - Stereo vision head
 - Dual arms and hands
 - » Compatible with existing EVA interfaces
 - Fits within EVA access corridors
 - Can utilize a variety of mounting and mobility options





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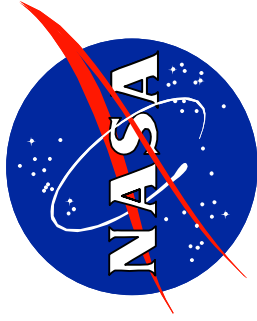
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Full Immersion Telepresence Testbed

- **Key Characteristics**
 - The operator is immersed in the remote world through a helmet mounted stereo display
 - Robot is slaved to the operator and follows operator body, arm and head motion
 - Capitalizes on the operator's innate ability to coordinate his own highly redundant body

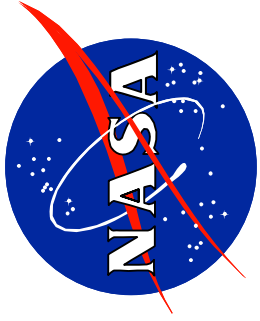




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ERA

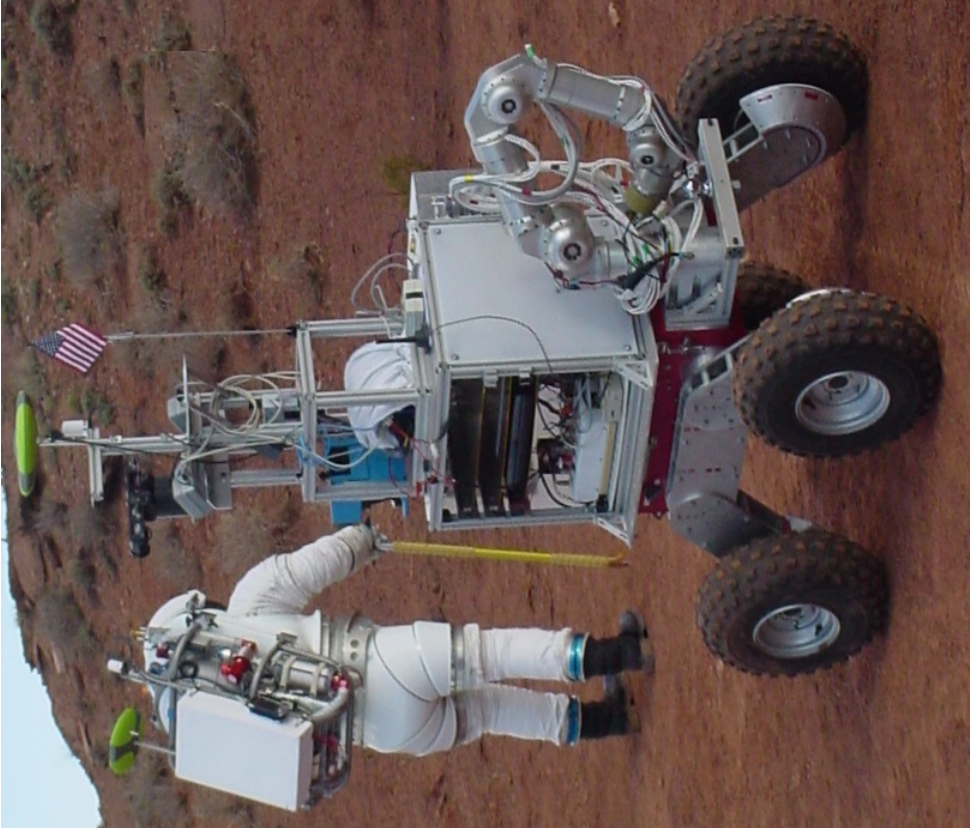
- The Extra-Vehicular Activity Robotic Assistant (ERA) is a wheeled robot used as a test bed for research into the requirements for successful collaboration between suited astronauts and autonomous robots. Through close partnership with the Advanced Spacesuit Lab at NASA-JSC, this robot participates in periodic field exercises with suited test subjects, where the human and robot work together to conduct space-relevant scenarios. The results of these field tests are then used to improve the robot and/or spacesuit, enabling the team to accomplish more complex scenarios.



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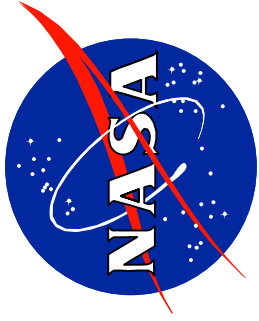
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ERA





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Psychological Aspects

- Humans demand & require ultimate control
- Relationship – Master/slave, Symbiotic, Autonomous
- Interactions – Dependent/Interdependent/independent
- Roles –
 - Human – Those tasks requiring final decision making
 - Robot – Those tasks that are too dangerous, monotonous, burdensome, or resource costly for humans
- Future robots